CAN-PCI/405

PCI-CAN Interface

Hardware Installation
and
Technical Data

to Product C.2023.xx

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Changes in the Chapters

The changes in the user's manual listed below affect changes in the **hardware**, as well as changes in the **description** of the facts only.

Chapter	Changes with respect to previous revision
-	Dimensions of the CAN-PCI/405-board changed
2.3	Description of the LEDs added

Further technical changes are subject to change without notice.

N O T E

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1. Overview

1.1 Module Description

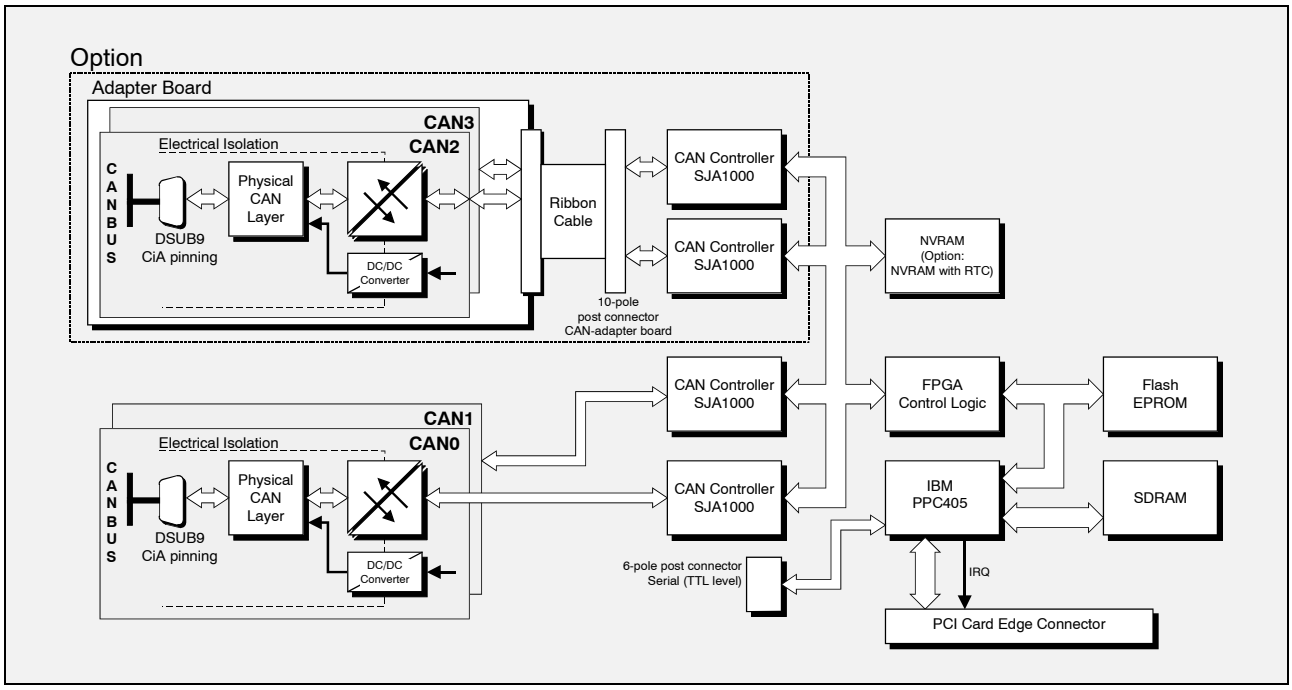


Fig. 1.1.1: Block diagram of CAN-PCI/405

The CAN-PCI/405 is a PC board designed for the PCI bus that supports up to four independent CAN interfaces. Two interfaces are placed directly at the board and two additional interfaces are placed at an adapter board.

The IBM PowerPC 405GP with 200 or 266 MHz enables a performance of up to 375 MIPS. The board is equipped with 16 or 64 Mbyte SDRAM and up to 8 Mbyte Flash. A non-volatile NVRAM enables the CAN-PCI/405 to save valuable process variables during power off sequences.

The CAN-PCI/405 produces hardware-generated timestamps with a resolution of 1 µs for all CAN messages.

The CAN-PCI/405 provides two ISO 11898 compliant CAN interfaces based on SJA1000 CAN controllers. The CAN interfaces allow a data transfer rate of 1 Mbit/s. The interfaces are electrically isolated from the other potentials.

Due to the powerful controller and the memory equipment it is possible for the customer to run his own applications locally at the CAN-PCI/405 module. esd offers several local operating systems for the module.

2. Hardware Installation

2.1 Procedure

Attention!
Electrostatic discharge may cause damage to electronic devices. In order to avoid this please follow the instructions below *before* you touch the CAN module to discharge your personal static electricity:

- Switch off the power supply of your PC but leave the connector plug in the socket.
- Then touch the metal case of the PC to discharge the static electricity.
- Furthermore you must avoid contact between your clothes and the CAN module.

Execute Hardware Installation:

1. Switch off the PC and all connected peripheral devices (monitor, printer, etc.). Switch off the CAN devices of the net to which the CAN module is to be connected.

2. Discharge yourself as described above.

3. Disconnect the power supply of the PC from the mains.

4. Remove the PC cover.
   Unfasten the mounting screws at the back of the PC and remove the cover.

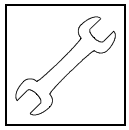
5. Select an open PCI slot and remove the slot cover at the back of the PC. Unfasten the screw which fixes the slot cover and retain it for fixing the module afterwards.
   The CAN module can be inserted into every PCI slot. Be careful not to insert the board into an ISA slot, because this might damage the PC and the board!

6. Insert the CAN module into the selected PCI slot.
   Carefully push the board down until it snaps into place.

7. Attach the board.
   Use the screw you removed from the slot cover in step 5.

8. If you are installing the CAN-PCI/405 module with 4 CAN interfaces you have to install the adapter board at the back of the PC at the PCI slot next to the CAN-PCI/405. Connect the two boards with the included ribbon cable. The cables connectors are reverse-connect protected.

➠➠



9. Replace the PC cover.
   Secure the cover with the according screws at the back of the PC.

10. Connect the CAN wire.
    Please note that the CAN bus has to be terminated at both ends! **esd** offers special T-connectors and terminator connectors. Additionally the CAN_GND signal has to be connected to earth at **exactly one** point. For easier wiring the termination connectors are equipped with an earth connector (4.8 mm fast-on, male).
    A CAN participant without an electrically isolated interface acts as an earth connection.

    The first CAN interface (CAN net 0) has to be connected via the lower DSUB connector (X1000) and the second CAN interface (net 1) has to be connected via the upper DSUB connector (X1010) of the CAN-PCI/405.
    If you are installing a CAN-PCI/405 with four CAN interfaces, you have to connect the third CAN interface (net 2) via the lower DSUB connector of the adapter board and the fourth CAN interface (net 3) via the upper DSUB connector of the adapter board. You will find a figure showing the connectors at page 8.

11. Reconnect the power supply of the PC.

12. Switch on the PC, the peripheral devices and the other CAN participants in any order.

13. End of hardware installation.
    The software installation is described in the manual ‘CAN-API, Installation und Software-Tools’.

2.2 PCB-View and Connectors

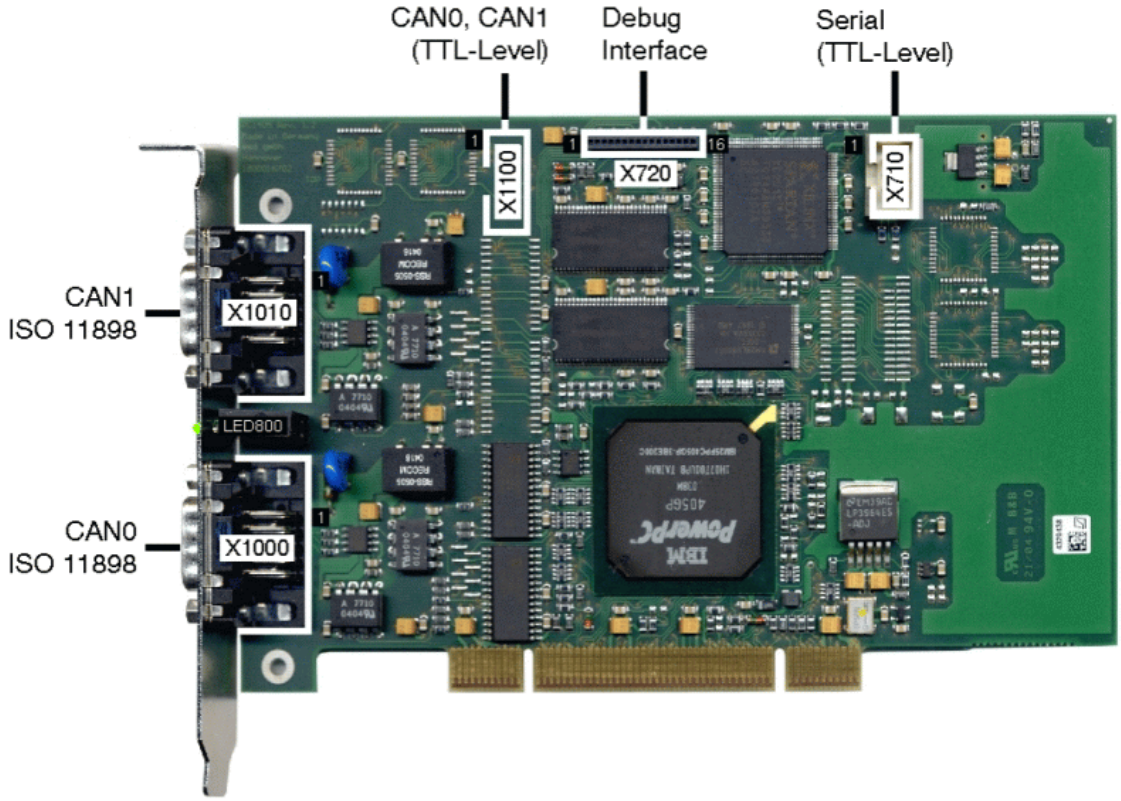


Fig. 2.2.1: View of the CAN-PCI/405 module

2.3 LEDs and Connectors in the Slot Cover

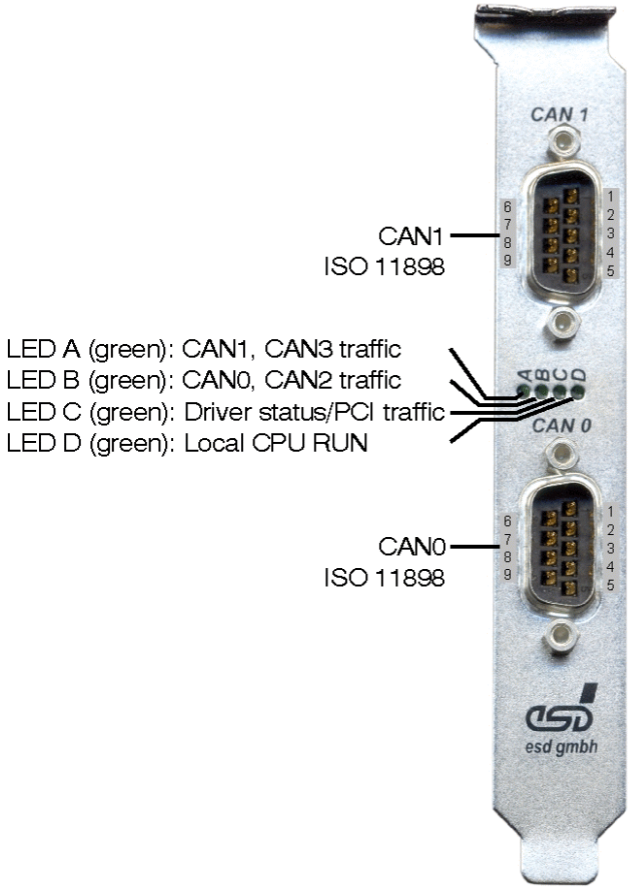


Fig. 2.3.1: Meaning of the LEDs and connector position

LED	Name	Description of LED (on)
A	CAN1-, CAN3-traffic	CAN-PCI/405-2: CAN-frames are being received or transmitted on CAN1 CAN-PCI/405-4: CAN-frames are being received or transmitted on CAN1 and/or CAN3
B	CAN0-, CAN2-traffic	CAN-PCI/405-2: CAN-frames are being received or transmitted on CAN0 CAN-PCI/405-4: CAN-frames are being received or transmitted on CAN0 and/or CAN2
C	Driver status/ PCI-traffic	LED off: No driver loaded LED on: Driver loaded LED flickering: Communication with CAN-board
D	Local CPU RUN	Local CPU is in RUN status (LED lights at every access to the SDRAM, therefore the LED can be blinking or permanently on in normal operation)

2.4 Option: 4 CAN Interfaces

As an option the CAN-PCI/405 can be ordered with four CAN interfaces.

This module type is equipped with two additional SJA1000 CAN controllers. The physical layer of the additional CAN nets is placed at a separate adapter board. The adapter board has to be mounted close to the CAN-PCI/405 and has to be connected by the ribbon cable that is contained in the scope of delivery.

The additional physical interfaces are designed identical to the physical interfaces of CAN net 0 and CAN net 1.

The four-CAN option has to be specified in order because it is not possible to build a four-channel module from a two-channel module afterwards.

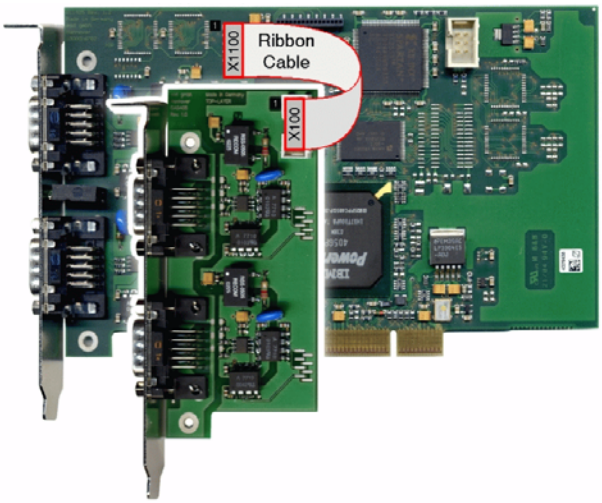


Fig. 2.4.1: Connection of the adapter board via ribbon cable

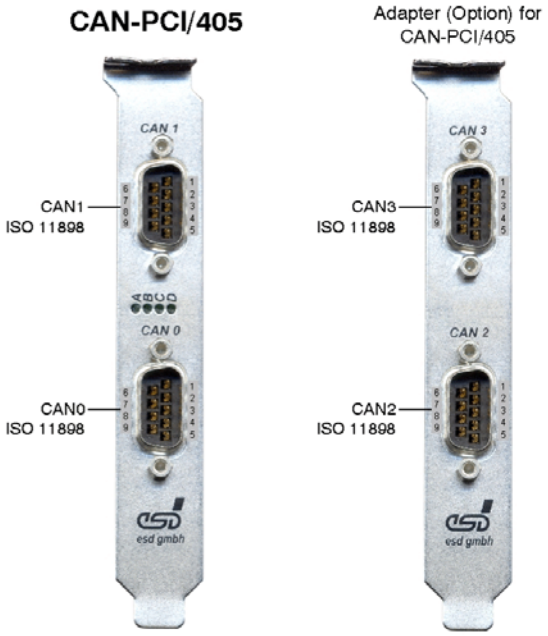


Fig. 2.4.2: CAN channel assignment to the connectors

3. Summary of Technical Data

3.1 General Technical Data

Ambient temperature	0...50 ˚C
Humidity	max. 90 %, non-condensing
Supply voltage	supplied by PCI bus, nominal voltage: 5 V ±5%, 3.3 V ±5%, typical current consumption for 2x CAN (max., at 20°C): 0,62 A at 3,3 V 0,13 A at 5 V
Plug-and-socket connectors	X100 (card edge) - PCI bus X1000 (DSUB9/male) - CAN net 0 X1010 (DSUB9/male) - CAN net 1 X1100 (10-pole post connector) - adapter board for CAN net 2 and CAN net 3 The following connectors are only equipped for programming and service: X720 (10-pole SMD female con.) - debug interface X710 (6-pole post connector.) - serial interface (TTL) The following connectors are on the adapter board P130 (DSUB9/male) - CAN net 2 P130 (DSUB9/male) - CAN net 3 X100 (10-pin post connector) - connector on the adapter board for the connection of the CAN-PCI/405-4 via ribbon cable
Dimensions	164.64 mm x 106.68 mm (without slot cover panel and CAN connectors)
Weight	< 200 g

Table 3.1.1: General data of the module

3.2 Microprocessor and Memory

CPU	PowerPC 405GP, 200/266 MHz, 32 bit
NVRAM	(1, 2, 4, 8 MB) 32 KB NVRAM (option)
Flash-EPROM	up to 8 M x 8 bit Flash EEPROM
SDRAM	from 4 M x 32 bit SDRAM (16 Mbyte) up to 16 M x 32 bit SDRAM (64 Mbyte)
Clock	Real time clock (option)

Table 3.2.1: Microprocessor and memory

3.3 PCI Bus

Host bus	PCI in compliance with PCI Local Bus Spec. 2.2
PCI data bus	32 bit
Controller	PPC405GP
Interrupt	interrupt signal A
Slot position	no restrictions for the slot position, PCI bridges are tolerated
Board dimension	PCI short card
Connector	PCI card edge connector

Table 3.3.1: PCI bus data

3.4 CAN Interface

Number of CAN interfaces	2, optionally 2 additional CAN interfaces at adapter board
CAN controller	SJA1000
CAN protocol	CAN 2.0A/B
Physical layer	Physical layer according to ISO 11898, transmission rate is programmable from 10 Kbit/s to 1 Mbit/s
Termination	has to be done externally
Electrical separation of CAN interfaces from other units and from each other	separation by means of optocouplers and DC/DC converters
DeviceNet Option	adapter board with Phoenix Combicon style connector, optocouplers and CAN driver acc. to DeviceNet specification 'DeviceNet Communication Model and Protocol, Rel. 2.0' as an option for each CAN net of the CAN-PCI/405 (has to be spedified in order)

Table 3.4.1: CAN interface data

3.5 Software Support

Software drivers are available for Windows, Linux and real time operating systems. The firmware can be loaded from the PC into the Flash EPROM.

The software installation and the software driver are described in the manual:

'CAN API with Software Tools and Installation Notes'
order no: C.2001.21

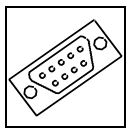
Software packages for CANopen or DeviceNet are available for Windows.

3.6 Order Information

Type	Description	Order no.
Hardware:		
CAN-PCI/405-2	2x CAN 2.0A/B, SJA1000	C.2023.02
CAN-PCI/405-4	4x CAN 2.0A/B, SJA1000 (incl. adapter)	C.2023.04
CAN-PCI/405-TTCAN	2 CAN-nets 2.0A/B, with 1x SJA1000 and 1x TTCAN	C.2038.02
Accessories:		
CAN-PCI/405-Slot	Adapter board with 2 CAN-nets, physical layer according to ISO11898 (2xDSUB)	C.2023.10
PCI-host software driver (incl. local firmware at CAN-PCI/405) :		
CAN-DRV-LCD	Layer-2 driver software Object licence for Windows and Linux incl. CD-ROM	C.1101.02
CANopen-LIC	CANopen Object licence for Windows and Linux	C.1101.05
CAN-PCI/405-IRIX	IRIX 6.5 software driver object licence	C.2023.27
Local operating systems for user applications running at the CAN-PCI/405:		
CAN-PCI/405-VxWOS	VxWorks-BSP adaption (board support package)	C.2023.30
CAN-PCI/405-LinuxOS	Linux-BSP	C.2023.32
Documentation:		
CAN-PCI/405-ME	User manual in English (this manual) [1*)]	C.2023.21
CAN-PCI/405-ENG	Engineering manual in English [2*)], Contents: schematic diagrams, PCB top overlay drawing, data sheets of significant components	C.2023.25
CAN-API-ME	Software manual for the host software driver in English [1*)]	C.2001.21

1*)... If module and manual are ordered together, the manual is free of charge.
2*)... This manual is liable for costs, please contact our support.

Table 3.6.1: Order notes for the CAN-PCI/405

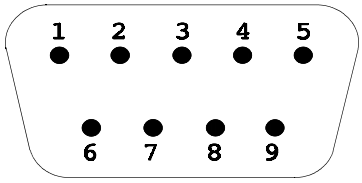


4. Connector Pin Assignment of the CAN Interfaces

4.1 CAN Interface at DSUB9 Connector

The assignment of the signals to the connector pins is the same for all CAN interfaces. All connectors are 9-pole DSUBs with male contacts.
Connectors on the CAN-PCI/450: X1000 (CAN0), X1010 (CAN1)
Connectors on the adapter board: P130 (CAN2), X170 (CAN3)
The DSUB connectors are not available, if the DeviceNet option is equipped.

Pin Location:



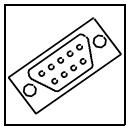
Pin Assignment:

Signal	Pin		Signal
		1	reserved
(CAN_GND)	6	2	CAN_L
CAN_H	7	3	CAN_GND
reserved	8	4	reserved
reserved	9	5	Shield

9-pole DSUB connector

Signal Description:

CAN_L, CAN_H...	CAN signals
CAN_GND ...	reference GND of the physical CAN layer
(CAN_GND)...	optional CAN-GND
Shield ...	connected to computer case via slot cover panel
reserved ...	reserved for future use



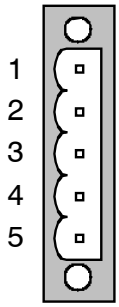
Connector Assignment

4.2 Option DeviceNet

The DeviceNet interface is designed according to the specification 'DeviceNet Communication Model and Protocol, Release. 2.0'.

The power supply of the CAN bus driver has to be supported from external and the wiring is done by Phoenix Combicon style connectors MSTB 2.5/-GF-5.08 (or equivalent).

Pin Assignment:



Pin Signals:

Pin	Signal
1	V-
2	CAN-
3	Shield
4	CAN+
5	V+

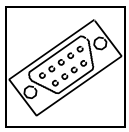
Signal Description:

V+... power supply for CAN interface (U_{VCC} = 24 V ± 4%)

V-... reference GND for V+ and CAN+/CAN-

CAN+, CAN-... CAN signals

Shield... shielding
(via high resistance RC-combination connected to earth via slot cover panel



4.3 Optional Adapter of CAN2 and CAN3

Signal	Pin		Signal
+5V	1	2	Tx0-CAN2*
Tx1-CAN2*	3	4	Rx0-CAN2*
Rx1-CAN2*	5	6	Tx0-CAN3*
Tx1-CAN3*	7	8	Tx0-CAN3*
Rx1-CAN3*	9	10	GND

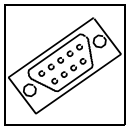
10-pole post connector

Signal Description:

Tx0-CAN2*, Rx0-CAN2*,
Tx1-CAN2*, Rx1-CAN2*... CAN signals (TTL-level) of the optional interface CAN2

Tx0-CAN3*, Rx0-CAN3*,
Tx1-CAN3*, Rx1-CAN3*... CAN signals (TTL-level) of the optional interface CAN3

+5V, GND ... power supply of the adapter board



Connector Assignment

4.4 Serial Interface at X710

The signals of the serial interface at X710 have **TTL-Level**!

Signal	Connector pin		Signal
+5 V	1	2	RxD
TxD/STR12	3	4	GND
CTS	5	6	RTS/STR14

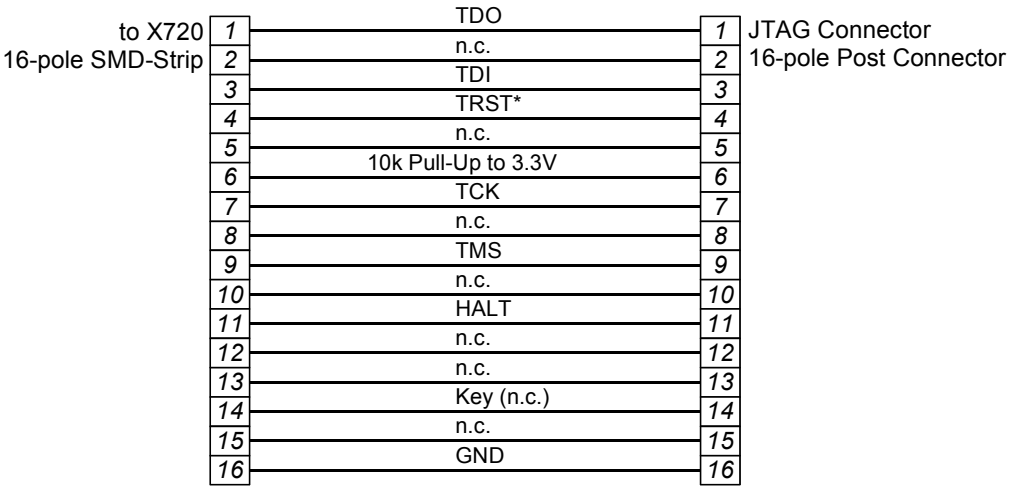
6-pole post conncetor

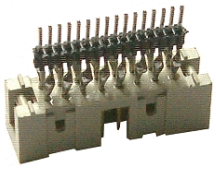
Attention: The signals at the pins 3 and 6 will not only be used as TxD- and RxD-Signals. In the boot sequence of the PPC405 these signals are used to define the setting of the operation mode (Strapping Pins). The level is defined by high-impedance local resistors on the board.
Therefore the user has to ensure, that no pull-up or pull-down resistors with values smaller than 10 kohm will be connected at the lines TxD/STR12 or RxD/STR14. This could happen with some modem types !

4.5 Debug Port X720

With the debug port e.g. firmware updates can be executed. It can be connected via a 16-pole SMD-pin contact strip connector. It is recommended to build a simple adapter from the SMD-pin contact strip connector to a 16-pin post connector to connect the port.

Attention: The SMD-pin contact strip connector case has no polarity! Take care to insert it into the correct position. The orientation of the pins of X720 is shown at page 6.





Example of an Adapter (Uncasted)

Connectors to build adapter:

SMD-pin contact strip:	Fa. Samtec, 'modified pin contact strip', order-no. MTMS-116-52-T-S-185
2.54 mm post connector:	i.e. Fa. Harting, 16-pole, straight, order-no. 09185167324

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5. Correctly Wiring Electrically Isolated CAN Networks

Generally all instructions applying for wiring regarding an electromagnetic compatible installation, wiring, cross sections of wires, material to be used, minimum distances, lightning protection, etc. have to be followed.

The following **general rules** for the CAN wiring must be followed:

1.	A CAN net must not branch (exception: short dead-end feeders) and has to be terminated by the wave impedance of the wire (generally 120 W ±10%) at both ends (between the signals CAN_L and CAN_H and **not** at GND)!
2.	A CAN data wire requires **two twisted** wires and a wire to conduct the reference potential (CAN_GND)! For this the shield of the wire should be used!
3.	The reference potential CAN_GND has to be connected to the earth potential (PE) at **one** point. Exactly **one** connection to earth has to be established!
4.	The bit rate has to be adapted to the wire length.
5.	Dead-end feeders have to kept as short as possible (l < 0.3 m)!
6.	When using double shielded wires the external shield has to be connected to the earth potential (PE) at **one** point. There must be not more than **one** connection to earth.
7.	A suitable type of wire (wave impedance ca. 120 Ω ±10%) has to be used and the voltage loss in the wire has to be considered!
8.	CAN wires should not be laid directly next to disturbing sources. If this cannot be avoided, double shielded wires are preferable.

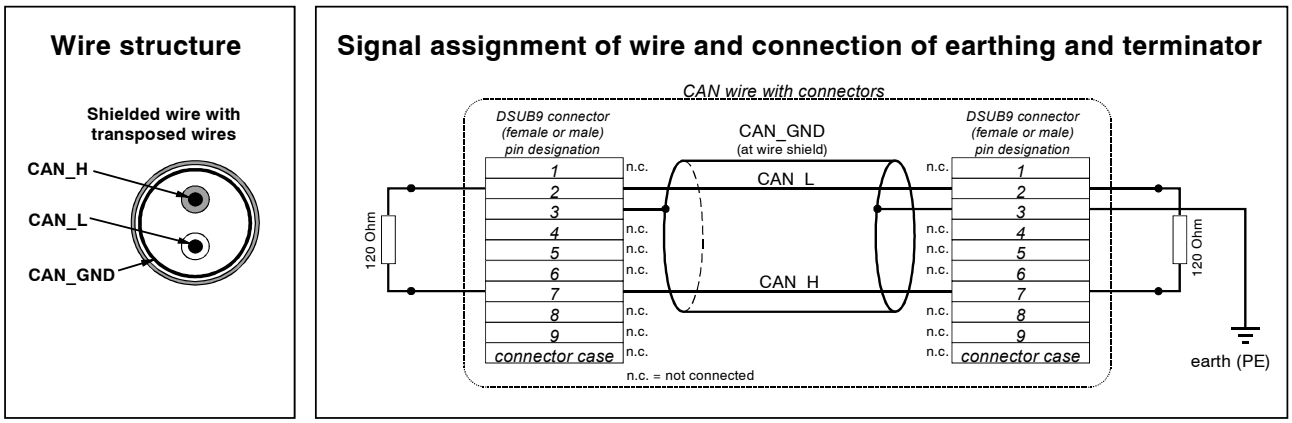


Figure: Structure and connection of wire

Cabling

- for devices which have only one CAN connector per net use T-connector and dead-end feeder (shorter than 0.3 m) (available as accessory)

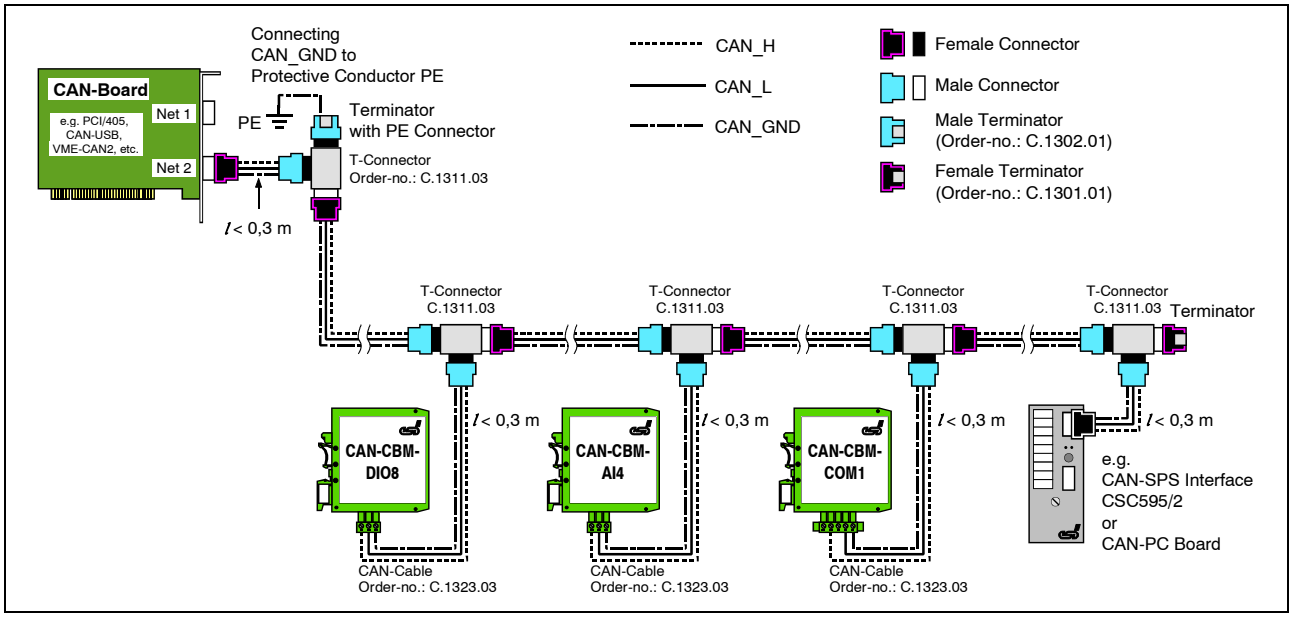


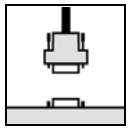
Figure: Example for correct wiring (when using single shielded wires)

Terminal Resistance

- use **external** terminator, because this can later be found again more easily!
- 9-pin DSUB-terminator with male and female contacts and earth terminal are available as accessories

Earthing

- CAN_GND has to be conducted in the CAN wire, because the individual esd modules are electrically isolated from each other!
- CAN_GND has to be connected to the earth potential (PE) at **exactly one** point in the net!
- each CAN user without electrically isolated interface works as an earthing, therefore: do not connect more than one user without potential separation!
- Earthing CAN e.g. be made at a connector



Wire Length

❍ Optical couplers are delaying the CAN signals. By using fast optical couplers and testing each board at 1 Mbit/s, however, esd CAN guarantee a reachable length of 37 m at 1 Mbit/s for most esd CAN modules within a closed net without impedance disturbances like e.g. longer dead-end feeders. (Exception: CAN-CBM-DIO8, -AI4 and AO4 (these modules work only up to 10 m with 1 Mbit/s))

Bit rate [Kbit/s]	Typical values of reachable wire length **with esd interface** l_{max} [m]	**CiA recommendations** (07/95) for reachable wire lengths l_{min} [m]
1000	37	25
800	59	50
666.6	80	-
500	130	100
333.3	180	-
250	270	250
166	420	-
125	570	500
100	710	650
66.6	1000	-
50	1400	1000
33.3	2000	-
20	3600	2500
12.5	5400	-
10	7300	5000

Table: Reachable wire lengths depending on the bit rate when using esd-CAN interfaces

Examples for CAN Wires

Manufacturer	Type of wire
U.I. LAPP GmbH Schulze-Delitzsch-Straße 25 70565 Stuttgart Germany www.lappkabel.de	e.g. UNITRONIC ®-BUS CAN UL/CSA (UL/CSA approved) UNITRONIC ®-BUS-FD P CAN UL/CSA (UL/CSA approved)
ConCab GmbH Äußerer Eichwald 74535 Mainhardt Germany www.concab.de	e.g. BUS-PVC-C (1 x 2 x 0,22 mm²) Order No.: 93 022 016 (UL appr.) BUS-Schleppflex-PUR-C (1 x 2 x 0,25 mm²) Order No.: 94 025 016 (UL appr.)
SAB Bröckskes GmbH&Co. KG Grefrather Straße 204-212b 41749 Viersen Germany www.sab-brockskes.de	e.g. SABIX® CB 620 (1 x 2 x 0,25 mm²) Order No.: 56202251 CB 627 (1 x 2 x 0,25 mm²) Order No.: 06272251 (UL appr.)

Note: Completely configured CAN wires can be ordered from **esd**.

6. CAN-Bus Troubleshooting Guide

The CAN-Bus Troubleshooting Guide is a guide to find and eliminate the most frequent hardware-error causes in the wiring of CAN-networks.

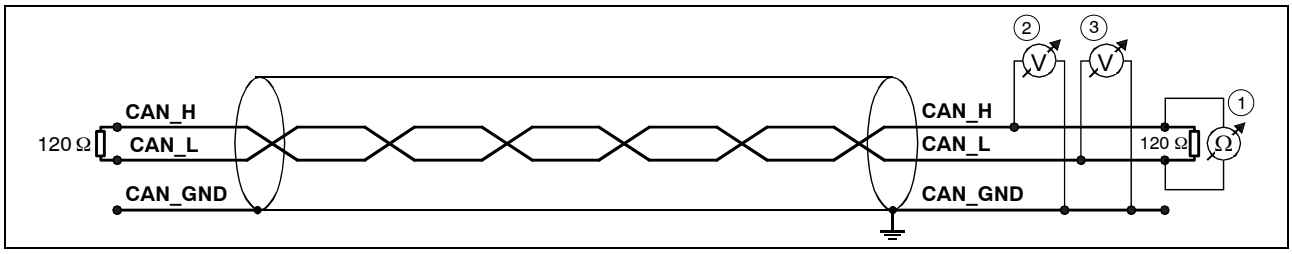


Figure: Simplified diagram of a CAN network

6.1 Termination

The termination is used to match impedance of a node to the impedance of the transmission line being used. When impedance is mismatched, the transmitted signal is not completely absorbed by the load and a portion is reflected back into the transmission line. If the source, transmission line and load impedance are equal these reflections are eliminated. This test measures the series resistance of the CAN data pair conductors and the attached terminating resistors.

To test it, please

1. Turn off all power supplies of the attached CAN nodes.
2. Measure the DC resistance between CAN_H and CAN_L at the middle and ends of the network (1) (see figure above).

The measured value should be between 50 and 70 Ω.

If the value is below 50 Ω, please make sure that:
- there is no short circuit between CAN_H and CAN_L wiring
- there are not more than two terminating resistors
- the nodes do not have faulty transceivers.

If the value is higher than 70 Ω, please make sure that:
- there are no open circuits in CAN_H or CAN_L wiring
- your bus system has two terminating resistors (one at each end) and that they are 120 Ω each.

6.2 CAN_H/CAN_L Voltage

Each node contains a CAN transceiver that outputs differential signals. When the network communication is idle the CAN_H and CAN_L voltages are approximately 2.5 volts. Faulty transceivers can cause the idle voltages to vary and disrupt network communication.

To test for faulty transceivers, please

1. Turn on all supplies.
2. Stop all network communication.
3. Measure the DC voltage between CAN_H and GND (2) (see figure above).
4. Measure the DC voltage between CAN_L and GND (3) (see figure above).

   Normally the voltage should be between 2.0 V and 4.0 V.
   If it is lower than 2.0 V or higher than 4.0 V, it is possible that one or more nodes have faulty transceivers. For a voltage lower than 2.0 V please check CAN_H and CAN_L conductors for continuity. For a voltage higher than 4.0 V, please check for excessive voltage.

To find the node with a faulty transceiver please test the CAN transceiver resistance (see next page).

6.3 Ground

The shield of the CAN network has to be grounded at only one location. This test will indicate if the shielding is grounded in several places.

To test it, please

1. Disconnect the shield wire from the ground.
2. Measure the DC resistance between Shield and ground.
3. Connect Shield wire to ground.

The resistance should be higher than 1 M Ω. If it is lower, please search for additional grounding of the shield wires.

6.4 CAN Transceiver Resistance Test

CAN transceivers have one circuit that controls CAN_H and another circuit that controls CAN_L. Experience has shown that electrical damage to one or both of the circuits may increase the leakage current in these circuits.

To measure the current leakage through the CAN circuits, please use an ohm-meter and:

1. Disconnect the node from the network. Leave the node unpowered (4) (see figure below).
2. Measure the DC resistance between CAN_H and CAN_GND (5) (see figure below).
3. Measure the DC resistance between CAN_L and CAN_GND (6) (see figure below).

Normally the resistance should be between 1 M Ω and 4 M Ω. If it is not within this range, the CAN transceiver is probably faulty.

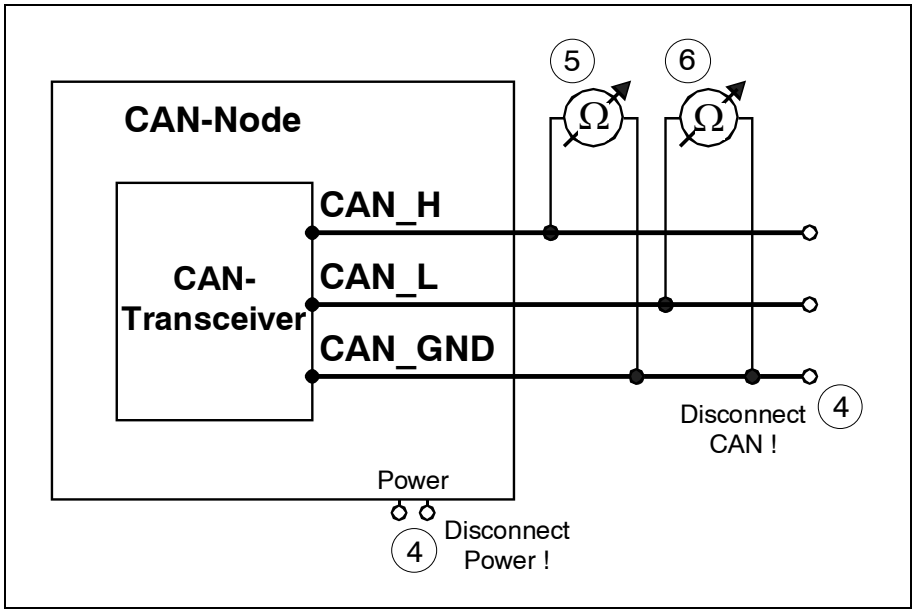


Figure: Simplified diagram of a CAN node